

common design concepts  
for the  
learning car mechanic

vol. 1 2023

by Magnolia Crescent

Hi!

There are lots of how-tos for specific jobs and explanations of each system in a car, but I wanted to make a zine to explain a few general concepts that show up over and over. What is GROUND, or TORQUE? What are SOLENOIDS, RELAYS, and BEARINGS? Those are some words you'll hear in lots of different contexts, and I think it helps to understand what they mean independent of context.

here we go...

# GROUND is a concept used in wiring.

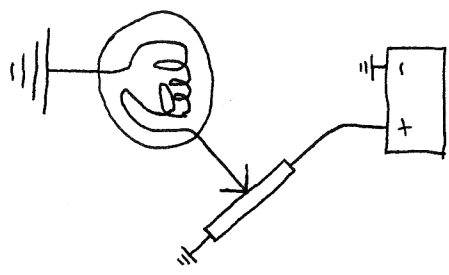
All electricity flows in a circuit, and in a car it's easiest to think of the circuit as starting and ending with the battery. Anything that gets power, like a headlight, needs to have a positive wire going to it from the positive post of the battery and negative wire going back to the negative post of the battery. But to make things simpler, and save wires, manufacturers don't run a negative wire back to the battery from every light. They just attach the negative wire from each light (or whatever electrical device) to the metal frame of the car, and also have a big wire from the battery negative post to the frame. That way the electricity can run through the frame instead of needing a wire. This is why a positive wire that breaks and touches exposed metal somewhere on the car will short out.

If you see some wires that seem to dead-end into a bolt holding them to the frame, that's a ground. Rusty or loose grounds can cause a lot of mysterious problems, so keep an eye out for them!

 the schematic symbol for ground

Sometimes there is no separate shaft, and no separate races. In a belt tensioner, the "inner race" is a mounting piece that's bolted to the engine and doesn't move; the "outer race" is the pulley itself. In a hub assembly type wheel bearing, the "outer race" bolts to the wheel knuckle and the "inner race" is the hub itself, which is attached to the spinning wheel of the car.

Over time, the balls and rollers inside bearings wear and lose material, so they don't fit tightly any more, and don't spin smoothly enough. When that happens, they can heat up from excessive friction, or start to have play from side to side or in and out. Eventually, if ignored, they'll break apart and whatever they're holding will fall out. You'll learn to recognize the warning sounds different kinds of bearings make when they become too worn.



Good luck out there!

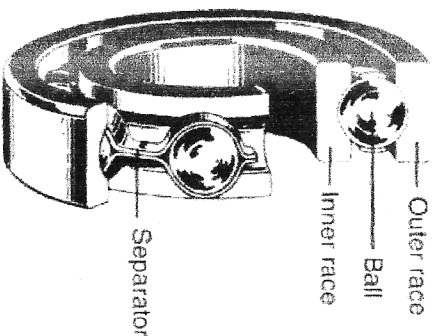
♡ Magnolia Crescent

However, torque doesn't translate directly into clamping pressure. The same torque can produce very different clamping pressure based on the angle of the thread of the bolt: finer thread gives more clamping pressure per foot pound of torque than does coarser thread. Also, since friction between the threads adds to the torque, the same amount of torque counts for less clamping pressure if the threads are rusty or dirty, and more if the threads are lubricated. (Torque specs are given for clean, dry thread unless they say otherwise.) Excessive torque twists off the head of a bolt, but excessive clamping force is what pulls the threads out of the hole--so if you go by feel, take into account the thread pitch and lubrication. A torque spec for dry thread can be too high and strip the hole if the thread is lubricated.

Different mechanics have different opinions about which things need to be torqued to spec.

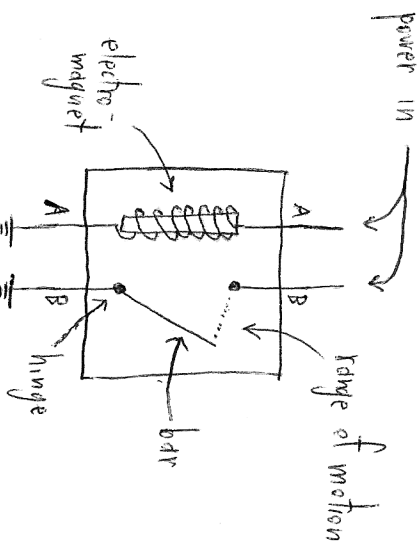
□ BEARINGS were too hard to draw so I had to steal some diagrams.

Bearings are for holding spinning shafts in place--that is, when they need to spin with as little friction as possible, but without moving side to side or in and out. They're called bearings because they're the points where a stationary object bears the weight of a spinning object or vice versa. They can be full of little balls, or tiny cylinders ("rollers"), or they can even be flat pieces of soft metal with oil channels in them. Everything involved in delivering power to the wheels has bearings: the crankshaft in the engine, the shafts in the transmission, the driveshaft (if it's rear wheel drive), and the axles are all held in place with bearings. The shafts inside power steering pumps, water pumps, AC compressors, and alternators have bearings.



Most bearings have an outer race (a solid piece that fits into a stationary object) and an inner race, which fits over the shaft.

□ RELAYS are electrical switches, but they're operated by electricity instead of by hand. One circuit turns another on and off, like this: when the first circuit (A in the drawing) gets power, it energizes a coil of wire around a piece of iron, which makes the iron into a magnet. The magnet pulls a bar into a slot, closing the second circuit (B). When circuit A is broken, the magnetism goes away, and a spring pushes the bar back to its starting place, which breaks circuit B.

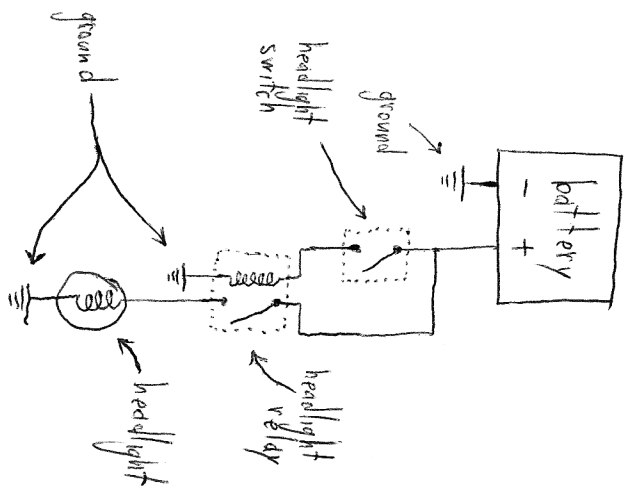


This kind of relay is "normally open"--that is, circuit B is open until the relay gets power. They can also be normally closed, so when A gets power, it breaks B.

Why would anyone make such a thing? Usually it's because they have a component, like a headlight, that draws a lot of power and needs a thick wire, and they want it to be turned on and off by a switch that's on a steering wheel or somewhere it would be inconvenient to run a thick wire to. The electromagnet in the relay draws very little power, and they can use a small wire to get power to it. (In this drawing, A is the low-power circuit and B is the high-power circuit.)

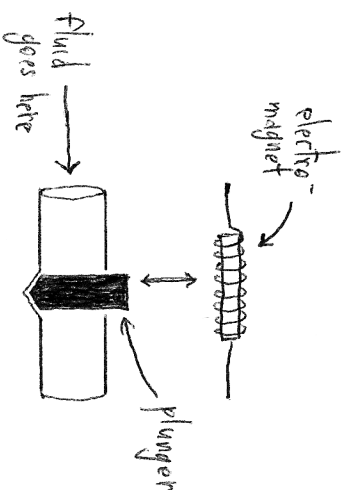
Think of a starter, which is right near the battery, and has a wire almost as thick as a finger, that you couldn't possibly get under the dash to the ignition switch--and would be dangerous if you did.

Relays usually look like square, plastic boxes an inch or two tall, and you can find them in fuse boxes under the hood and under the dash.



a possible circuit using a relay

**SOLENOID VALVES** are like relays, but the circuit controls the flow of a fluid instead of another circuit. A tube full of brake fluid, or transmission fluid, or vacuum, has a plunger that blocks it. Instead of pulling a bar, the electromagnet pulls the plunger to open or close the passageway.



Solenoids are used to quickly open and close brake lines in the ABS modulator, which "pumps" the brakes for you when your anti-lock brakes kick in. They also allow the computer to use fluid pressure to engage the clutches in an automatic transmission at the right time to shift gears. On older cars, you might find solenoids opening and closing vacuum lines to lock and unlock the doors automatically.

This drawing is an idealized version, they don't actually look like this. They can look like a plastic box, or be built into the side of a transmission where you only see an electrical connector sticking out, with a bolt or two holding the solenoid in.

## TORQUE is a measure of force.

The more you turn a bolt, the tighter it clamps down on anything sandwiched in between the head of the bolt and the hole or nut it threads into. There's no practical way to measure clamping pressure, so instead we measure torque, or the amount of force directed toward turning the head of the bolt: we measure how much "weight" we put on the end of our wrench. Since the same amount of weight produces more force at the end of a long lever than a short one, we give the measurement in both length and weight: foot-pounds (or newton-meters in metric). 20 foot pounds is the amount of torque produced by 20 pounds on the end of a foot-long lever, measured from the center of the bolt. Torque is measured with a torque wrench.

